Broadcasting & Cable
The Newsweekly of Television and Radio
August 9, 1993

CellularVision, Bell Atlantic to unwire N.Y.

Telco, wireless cable firm plan super-high-frequency service within two years

By Rich Brown

Bell Atlantic and CellularVision of New York plan to give 6.3 million New Yorkers a wireless TV alternative to cable within the next two years.

Bell Atlantic plans to cover the region with as many as 35 cell sites that will transmit wireless signals in the 28 ghz spectrum. Its new-found partner, CellularVision, is the only company in the country with FCC approval to deliver video signals over the super-high frequency.

CellularVision, which won its go-ahead from the FCC last December, delivers 49 channels for $29.95 a month to about 200 subscribers in Brighton Beach, N.Y. Programming is received via a five-inch window-mounted antenna and a set-top box the size of a videocassette recorder.

Eventually, the CellularVision technology will accommodate up to 100 channels, high-definition TV, personal communication services, two-way data transmission, video on demand, local transactional services and remote health-care and educational services, according to CellularVision CEO Shant Hovnanian.

"Today it's a platform for cable; in the 21st century it has the potential for growing into a full-service network," says Brian Oliver, president, business development, Bell Atlantic Enterprises International. Bell Atlantic will operate the New York system, which the companies hope to begin marketing next year.

Executives at Bell Atlantic and CellularVision said it will cost "hundreds of millions" of dollars in capital infrastructure to make the system available to the first 500,000 subscribers. Bell Atlantic, which has annual revenues of $12.6 billion, has purchased an undisclosed stake in the privately held wireless company. But Bell Atlantic does not have an equity stake in the patented wireless technology, which is owned by spin-off company CellularVision Technologies & Telecommunications.

No regulatory approval is needed to move forward on the project in the New York area. On a national scale, the FCC is expected to decide in 1994 whether to allow video delivery in the 28 ghz spectrum. In the event the FCC gives a green light to a national roll-out, Oliver says, their operational experience in the New York area will give Bell Atlantic and CellularVision an advantage in taking the technology to other markets. Oliver says Bell Atlantic plans to work with both wired and wireless companies to deliver video programming.

The CellularVision service will eventually be marketed to an area of 8.5 million people, including the five boroughs of New York City and the adjacent Westchester, Rockland and Putnam counties. The wireless service will serve many areas in the region where coaxial cable systems cannot afford to lay wire, says Oliver.

While CellularVision's costs might be lower than those of coaxial cable systems, critics point out that the wireless technology is more sensitive to geographic conditions. CellularVision executives acknowledge that trees create line-of-sight problems for the technology, but they say such problems can be corrected by properly routing the signal. ■

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THE WALL STREET JOURNAL
MARKETPLACE
August 5, 1993

Bell Atlantic Takes On Cable In Wireless Pact

By Mary Lu Carnevale
Staff Reporter

Bell Atlantic Corp. announced an alliance with a tiny New Jersey company to blanket the New York City area with an interactive, wireless television service that would compete with cable TV.

The alliance with **CellularVision of New York** Inc. will use an innovative microwave technology to compete head-to-head with cable systems in New York's five boroughs and three neighboring counties. Eventually, it could also compete with Nynex Corp.'s New York Telephone unit, offering an array of advanced telephone and data services.

The digital system punctures conventional wisdom that future multimedia services will be delivered over cable or phone wires into homes and businesses. It makes use of a flat, four-square-inch antenna that's mounted on a window and that costs about half as much to install as cable.

Nonetheless, Richard Aurelio, president of Time Warner Inc.'s Time Warner New York City Cable Group, said CellularVision's technology doesn't pose any immediate competitive threat. It has "severe limitations, including limited channel capacity and problems with signal quality and reliability," he said.

The new technology was invented by Bernard Bossard, a co-founder of CellularVision of New York. The Freehold, N.J., partnership includes real-estate developers Vahak Hovnanian and his son, Shant. Bell Atlantic holds a minority stake, and has a management contract to build and operate the TV service. Terms of the pact weren't disclosed.

A sister company, CellularVision Technologies & Telecommunications Inc., holds the patents on the new technology, which could open the way for local phone companies to provide two-way video services and other advanced telecommunications, including high-speed data services, movies on demand and video-teleconferencing services. In the future, it also could be used to provide ordinary phone service for residential and business customers.

For the next year or so, CellularVision of New York will be the sole user of the technology. Last December, CellularVision was awarded a special FCC license for pioneering the technology. The license covers operations in the five boroughs of New York, along with Westchester, Rockland and Putnam counties.

When it granted the license, the FCC proposed setting up a new telecommunications service using the 28 gigahertz band – a frequency that has been considered too high to be useful for commercial purposes. But the FCC is likely to take a year or so to adopt rules defining the new service and to set up procedures for auctioning the spectrum to companies that would build local systems.

Unlike cable TV, the CellularVision system sends TV signals through the air at very high frequencies – the 27.5 to 29.5 gigahertz microwave band. The network uses a series of transmitters, each of which is capable of broadcasting a digital signal within a six-mile radius. The signal is picked up at each subscriber's house by the window-mounted antenna, which is connected by coaxial cable – the type of wiring used by cable-TV companies – to a decoder that sits on top of the TV set. Although it could take hundreds of transmitters to serve the New York region, a microwave network would cost far less to build than stringing fiber-optic or coaxial cable past the homes or offices of every potential customer.

The partnership has been providing 49 channels of cable-TV programming, including some premium channels, to about 200 customers in Brooklyn's Brighton Beach neighborhood for $29.95 a month, substantially less than comparable cable-TV service. At a news conference announcing the partnership with Bell Atlantic, Shant Hovnanian said CellularVision would like to begin marketing the service next year.

The company's main focus so far this year has been finding a strategic partner, Mr. Hovnanian said. CellularVision now will turn to the task of developing a plan to roll out the service. "We plan to have the service available to as many areas as we can get to over the next two years," he said. A partner like Bell Atlantic, he said, will let the company build the network relatively quickly.

Brian Oliver, president of business development for Bell Atlantic's Bell Atlantic Enterprises International unit, declined to discuss the cost of building the New York system or to speculate on how long it might actually take. "We will develop plans, pursue the market based on those plans, take a look at where we are in two years," he said.

But Time Warner's Mr. Aurelio noted that "the high end of the frequency spectrum has never been used before for good reason," adding that the signal tends to fade in inclement weather. "CellularVision is claiming they've got some of these problems licked, but it is unproven," he said. Time Warner, along with U S West Inc., has embarked on a $5 billion project to upgrade its cable systems to provide interactive-TV and telephone services.

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TELEPHONY
Overland Park, KS

WEEKLY 46,802

JUN 30, 1993

It's in the air: Broadband Goes Wireless

TELEPHONY'S TECHNOLOGY UPDATE

Vendors are developing radio technology in the 28-GHz band that will enable telcos to offer voice as well as broadband data and video—sans wires. Could the residential last mile go wireless?

RICHARD KARPINSKI, TECHNICAL EDITOR

Conventional wisdom says the race to lay the information highway will be won by the companies that can most quickly and affordably wire up America with fiber and coaxial cable.

But what if a telephone company could "wire up" the country for broadband services without any wires at all? And do so for just a fraction of the cost of stringing fiber and coax strands or, as the cable industry plans to do, deploying large numbers of digital compression boxes?

That is the proposition being put forth by a handful of mostly small start-up firms that are pursuing a new type of wireless service, known in Federal Communications Commission parlance as local multipoint distribution service (LMDS).

Operating in the ultra high-frequency, or wave millimeter, range of the spectrum band—around the 28-GHz band—this technology promises telcos the ability to offer the same types of bandwidth usually associated with fiber optic cables. Indeed, the rapidly maturing radio technology could tempt telcos to rethink their local loop plans. The radio frequency (RF) technology could replace fiber/coax distribution links at about one-eighth the cost, sources say.

Through careful system design, the technology could even provide video-on-demand, with telcos demultiplexing fiber-delivered channels at the pedestal and then beaming individual, narrowcast channels to the home, says Robert Rosenberg, president of Insight Research Corp., a Livingston, N.J., telecom market research firm.

Thus while 28-GHz technology is "still an unfolding story," says Rosenberg, it "could allow telcos not only to leapfrog the cable TV industry but leave them in the dust."

Others, such as John Ryan, analyst at San Francisco-based Ryan, Hankin & Kent, are more reserved. His numbers show an LMDS system can be built for $800 per subscriber, though he has seen some estimates as low as $250. That low cost, plus the key fact that radio waves by their nature "pass every home in every city," means "you could put an antenna up Sept. 1, finish the engineering by Sept. 10, take out an ad the next week and by Christmas be taking in money," he says.

Forget massive satellite dishes. CellularVision's windowsill-mounted receiver antenna is five inches square.

However, providing more than one 1.5-Mb/s channel per home "could be stretching it," Ryan believes. That makes 28-GHz technology a good solution for low-cost, broadcast-only, out-of-region overbuilds, but not for the type of highly interactive, multimedia systems some vendors claim it can support, he says.

Bringing new attention to this technology was the recent minority investment by Bell Atlantic in CellularVision of New York, which operates a 28-GHz distribution system that delivers 50 video channels (soon to be increased to 100 channels) to several hundred subscribers in Brighton Beach Brooklyn (Figure 1). Bell Atlantic will operate the system and market the service in the metro New York area.

CellularVision has been operating in New York under a special FCC license since July 1992 (it holds a second license in Los Angeles, as well). Last December, the FCC began a rulemaking to license 2 GHz of spectrum—between 27.5 GHz and 29.5 GHz—with the idea of authorizing two operators to use 1000 MHz each per region to offer broadband video, data and even voice services. The commission is expected to sanction an auction of 28-GHz spectrum later this year.

That the FCC was licensing such a large chunk of spectrum caught the eye of Bell Atlantic, says Brian Oliver, president of business development at Bell Atlantic Enterprises International. Although admitting that the "jury is still out" on the technology, he says that if it reaches its potential it could represent a "seismic shift" in technology along the lines of the move from mainframe to PCs. For that reason, Bell Atlantic considers 28-GHz technology "part of the family of technologies" for building networks in the 21st century, he says.

"We've heard from all the naysayers," Oliver says. "We had some skepticism like everyone else. But if you think it's not going to work out, you'd better be sure. If not, you're putting yourself at significant corporate risk."

To deliver service, the CellularVision system covers an area with multiple cells, generally two to three miles in diameter (about 100 times smaller than a cellular telephone cell). Within each cell, 1 GHz of frequency is used to deliver 49 video channels, with each channel consisting of an FM signal

continued on page 18

occupying a 20-MHz slot (compared to 6 MHz for an analog cable TV channel).

Coupling smaller cells with higher bandwidth channels enables the system to run on much lower power. The system transmits only 10 milliwatts per channel over a three-mile radius system, getting better signal-to-noise ratio, and thus better voice quality, than cellular phones.

The system delivers a video signal from a satellite to the central system cell.

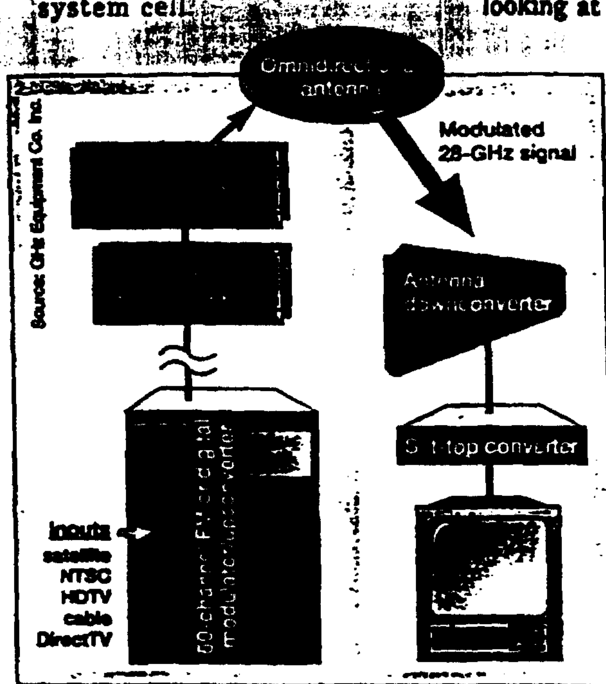

FIGURE 1 28-GHZ VIDEO DELIVERY SYSTEM

That signal is then spread to adjacent cells via 28-GHz point-to-point links. Each individual cell then uses a single omnidirectional transmitter to deliver the signal to a windowsill-mounted antenna, approximately five-inches square. A set-top box in each home delivers the signal to the TV.

Through a technique called reverse polarization, return-path communications channels can be inserted for transmission between the video channels. Through the efficient reuse of spectrum, the system can support up to 400,000 telephone lines per cell, as well as handle personal communication services (PCS), data transmissions and transactional banking and shopping services, says Bernard Bossard, inventor of the technology and chief engineering officer.

Along with Bell Atlantic and its microwave vendors, M-A/Com and Alpha Industries, CellularVision will continue to develop a more fully functional system, capable of delivering greater numbers of channels and increased interactivity, Bossard says.

Although CellularVision in Brooklyn operates as a stand-alone system, the technology could prove even more powerful as an extension to an existing fiber-trunked landline network, says Bell Atlantic's Oliver, adding that his company is looking at both in-region and out-of-region applications of the technology.

A handful of other vendors is developing 28-GHz technology as well. Prescott, Ariz.-based GHz Equipment Co. Inc. is working with David Sarnoff Research Center to develop a 28-GHz video delivery system, with the first systems scheduled to be available this fall. The company reportedly has been under consideration for several international contracts, including a major deal in Venezuela. Dudley Laboratories, in Toms River, N.J., is another 28-GHz firm led by former Sarnoff executive Henry Dudley also reportedly in the running for the Venezuelan deal.

Another nascent vendor, Video/Phone Systems Inc., of Stamford, Conn., is moving its focus beyond just video delivery to the creation of a complete telephony broadband delivery system, says Mark Foster, the company's chairman. Video/Phone has been developing a proprietary digital broadband technology called NarrowBEAM Cellular Transmission, which will provide duplex and half duplex broadband millimeter wave local links, Foster says. "We have developed an extension of the wireline telephone system, not a replacement," Foster says, adding that the system will be finalized in 30 days and will be shown to a group of telcos at that time.

For all its strengths, 28-GHz technology has had to overcome some potentially debilitating hurdles. The technology works best when receivers are in the line of sight of system transmitters, but that problem has been solved through the carefully engineered use of repeaters and reflectors. Other problems include multipath ghosting due to interference between adjacent cells and signal attenuation due to rain. "Have [the problems] been solved?" asks analyst Ryan. "[Through engineering] they certainly are being alleviated."

In addition to potential technical roadblocks, 28-GHz radio could present some regulatory hurdles as well. Some users, including NASA, have expressed concern that operations in that band could impact existing services. Further, it is not yet clear whether the FCC will even allow telcos to acquire 28-GHz wireless spectrum in areas where they operate a landline network. The cost of acquiring that spectrum is another unknown. Several sources indicated that carriers were trying to keep the hype low on 28-GHz technology, hoping to avoid a gold rush on the spectrum such as is expected when the FCC auctions off PCS licenses.

Indeed, most telcos and large vendors contacted about the technology were somewhat cagey, leaving the impression that although they were unwilling to talk on the record, the technology was simmering in the back rooms of their labs. DSC Communications, for instance, "is actively involved in looking at radio as the last link in getting to the home, but we're not at this point ready to make any product announcement," says a company spokesman. Bellcore, which has done work on an RF broadband distribution system known internally as asymmetrical digital microcell links, declined to talk on the record about its work, citing proprietary research.

Meanwhile, U S West confirmed it has been testing the technical characteristics of 28 GHz as a possible broadband delivery vehicle, but additional details from the company were slim.

CellularVision's Brossard says, "I don't know any telcos at this point that are negative about it. And I don't know anybody who says it won't work." ■

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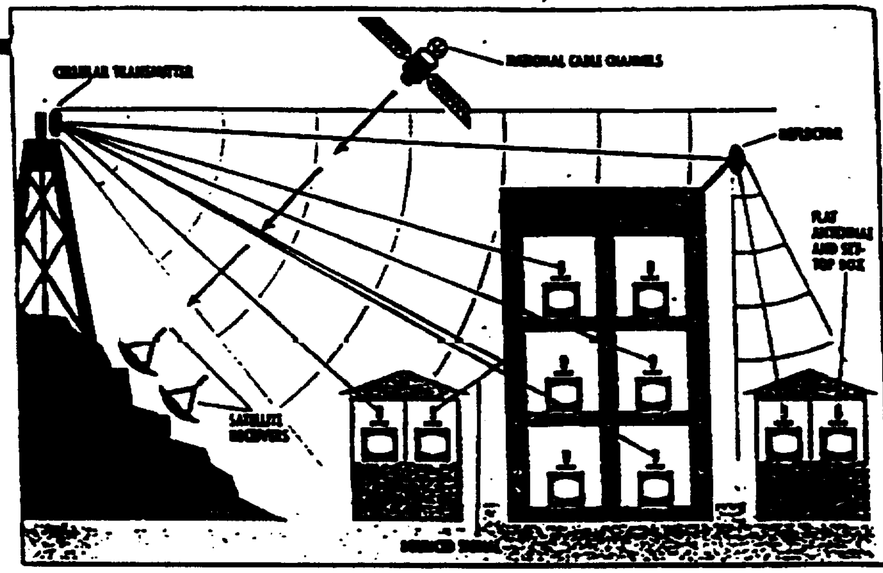
ELECTRONICS

EDITED BY MICHAEL ANTONOFF

TELEVISION

WIRELESS CELLULAR CABLE



CellularVision's satellite dishes receive cable channels and relay the signals along straight or bounced paths to five-inch antennas in neighborhood homes. The transmitter tower could be a tall building.

Alongside a water tower atop an apartment house in Brooklyn's Brighton Beach, a silver-dollar-size transmitter beams 50 cable channels to a section of that borough that still doesn't have cable TV. Reception is clear, a couple of premium channels like Showtime are included, and subscribers pay less than they would if they were wired up to receive the equivalent cable service.

CellularVision of New York, the system's operator, also retransmits regular broadcast TV channels at the super-high frequency, so viewers have replaced traditional rabbit ears with set-top boxes and flat antennae about the size of a cow's tongue. You can see them sprouting from windows as far away as Sheepshead Bay, a neighboring community. In one apartment there, CellularVision has set up a demonstration receiver with two-way video capabilities for video conferencing, a service it plans to offer in the future. Though the residence has line of sight to the transmitter, the signal can also be bounced off walls or bent around corners via simple reflectors.

Only the Brooklyn cellular TV site, limited in power to a three-mile radius, is now operational. But thanks to a recently announced agreement with Bell Atlantic, the regional phone company south of New York, CellularVision plans to expand its operation to dozens of sites in the metropolitan area—and later to Los Angeles—which could give cable operators real competition.

CellularVision uses a relatively inexpensive multicell, point-to-multipoint distribution system operating in the 27.5- to 29.5-gigahertz microwave band. The company has the first license from the Federal Communications Commission to use the frequencies for terrestrial broadcasting. The technology was invented by Bernard Bossard, the company's chief engineer. Customers pay about $29.95 a month.

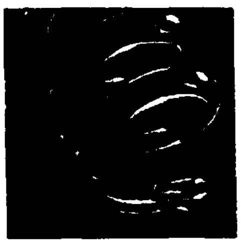
ECONOMIST
London, England

WEEKLY 349,000

OCT 23, 1993

Saw it on the radio

The picture is clearer for viewers than for the industry



IN A sparsely furnished flat in Sheepshead Bay, deep in the endless canyons of Brooklyn backstreets, Bill McKissock is flicking across the 49 channels delivered to his television by cable. Nothing unusual about that, except that this television is not wired in to the local cable-TV network. Instead it is attached, via a black box the size of a CD player, to a tiny, 13-centimetre-square antenna on the window-sill; this, in turn, is picking up programmes from a microwave transmitter about a mile away. In doing so, it is demonstrating one of the most astonishing applications yet of wireless technology.

Designed by CellularVision of Freehold, New Jersey, the system operates at frequencies high up in the microwave band of the radio spectrum. At that sort of frequency a lot of things ought to go wrong. For a start, the millimetre-long microwaves bounce off buildings, rather than going straight through them. That means microwave systems tend to work only when the receiver is in line-of-sight of the transmitter. Moisture is another headache. When it is raining heavily, the quality of microwave transmissions falls sharply. Hardly a practical rival to the cable-TV network.

CellularVision's system, at present serving about 400 trial subscribers in Brooklyn, gets round these problems. The company's technology is based on cells, just like a traditional cellular-telephone network. But the cells in CellularVision's system are much smaller, with a radius of about five kilometres. The transmitter at the heart of each cell operates at very low power but, because there is plenty of unused radio spectrum available at microwave frequencies, can transmit with an exceptionally wide bandwidth. CellularVision's system has around 300 times the bandwidth of conventional broadcast television, and more, even, than the average cable-TV system. With so much bandwidth, the network can shrug off all but a Brooklyn monsoon. And the problem of a multitude of signals bouncing off buildings is solved by using what is known as a "narrowband" antenna, which simply locks on to the strongest transmission.

"We don't have the infrastructure costs of cable," says Mr McKissock, who is CellularVision's general manager, "so we can charge up to 40% less for the service." At a time when complaints about the cost of cable television in America have never been louder, that could be useful; so could the quality of CellularVision's sound and pictures, which easily beats that of most cable networks. And with a different sort of set-top receiver and antenna, CellularVision's system can also provide interactive television, data transmission, a telephone service and videoconferencing. Small wonder that, on August 4th, Bell Atlantic, one of the most innovative of America's Baby Bells, took an undisclosed stake in CellularVision.

Cash from Bell Atlantic will let CellularVision build a $15m network covering New York city and its outer boroughs; the FCC has already awarded the company a licence to operate the service. In the long term, however, Bell Atlantic has more ambitious plans for the technology. It could be used to provide the final link between kerbside cable and individual households for a mass of interactive services. That would fit Bell Atlantic's strategy, especially given its planned merger with TCI. It wants to compete in the cable business in its east-coast telephone-service area, and in late August won the first round of a legal battle to be allowed to do so (at present the Baby Bells are forbidden from offering cable TV in their own regions). Like many other Baby Bells, the firm is also keen to form an alliance with a big cable company. CellularVision's technology could also be used to compete with rival telephone firms in the local loop. Or it could bypass traditional phones and cable systems altogether.

Bell Atlantic's vision is shared by others. TV Answer, a company based in Reston, Virginia, has designed a wireless, interactive television system which should be up and running some time next year. And then there is a new generation of satellite-TV services, which use digital transmission and compression techniques to squeeze ten channels into the bandwidth previously occupied by just one. The first service, Hughes Communications' DirecTV, is scheduled to launch next year with up to 150 channels. The $1 billion project aims to steal 10m viewers from cable and broadcast television by the end of the century. "Cable is going to be under assault, no question," says Peter Huber.

The driving force behind all of this is software. Already, the inside of a typical digital cellphone resembles nothing so much as a miniature desktop computer; GSM handsets have up to 450,000 lines of computer code burned into their memories. As the power-to-price ratio of microprocessors climbs, and the cost of memory chips becomes negligible, the capabilities of cellular software will soar.

The intricate mathematics of "fractal compression" software, which allows pictures to be transmitted at high speed over wireless networks, points to the possibilities. Fractal compression works by analysing each picture to see which bits recur elsewhere in the image. It then sends a sample of each—say, a blob of blue sky—along with digital instructions about how to replicate it to reconstruct the picture. Normally, a colour image might take more than an hour to transmit over a telephone network; fractal compression cuts that by a factor of 50 or more. By applying similar techniques to voice transmission, notes Mr Huber, "digital compression technology will expand the capacity of cellular telephone networks to 15 or 20 times present levels." As with many clever telecoms technologies, compression was dreamed up by the military.

The rigours of reality

The wireless industry, then, is in a state of barely concealed excitement. Digital technology appears to be rewriting the laws of the radio spectrum, gleaning extra capacity where none was previously thought to exist. Companies such as CellularVision are discovering all sorts of new ways to make wireless networks carry as much information as cable, but without the need to dig up roads and driveways. In rich countries, consumers seem eager to free themselves from the tyranny of the telephone wire, and—despite well-publicised scares that cellphones might cause brain cancer—are buying mobile telephones in their millions. In poor countries, desperate for telephones of any kind, the speed with which wireless networks can be put in place is boosting sales beyond the industry's wildest dreams. And businesses, eager to make the best use of their roving employees, are keeping them busy with messages sent over the airwaves.

The long-term challenge for the wireless-communications industry is to turn all this into profits. In many ways, what is now happening in the business parallels what has taken place in the personal-computer industry in the past three years. In rich countries, cellular telephones, like personal computers, are now for the most part commodity goods. Few pocket cellphones are very different in size or quality from their rivals, which means all must compete on price alone. Worse, most consumers cannot see why a cellular telephone should cost any more than the $100 cordless telephone they have at home. Traditionally, this has not been a problem for cellular operators, who have long subsidised cellphone prices out of the profits they make on

This survey has drawn on a variety of published and unpublished sources. Two books, in particular, should be mentioned: The Geodesic Network II: 1993 Report on Competition in the Telephone Industry, by Peter Huber, Michael Kellogg and John Thorne (The Geodesic Company, Washington, DC) and Wireless [illegible] the Local Telephone Network, by [illegible]

First, catch your telephone

calls. The trouble is that those profits are shrinking rapidly. Struck dumb by the exorbitant cost of cellular calls, the typical cellular-telephone user now spends only one-third as much on calls as he did in the mid-1980s.

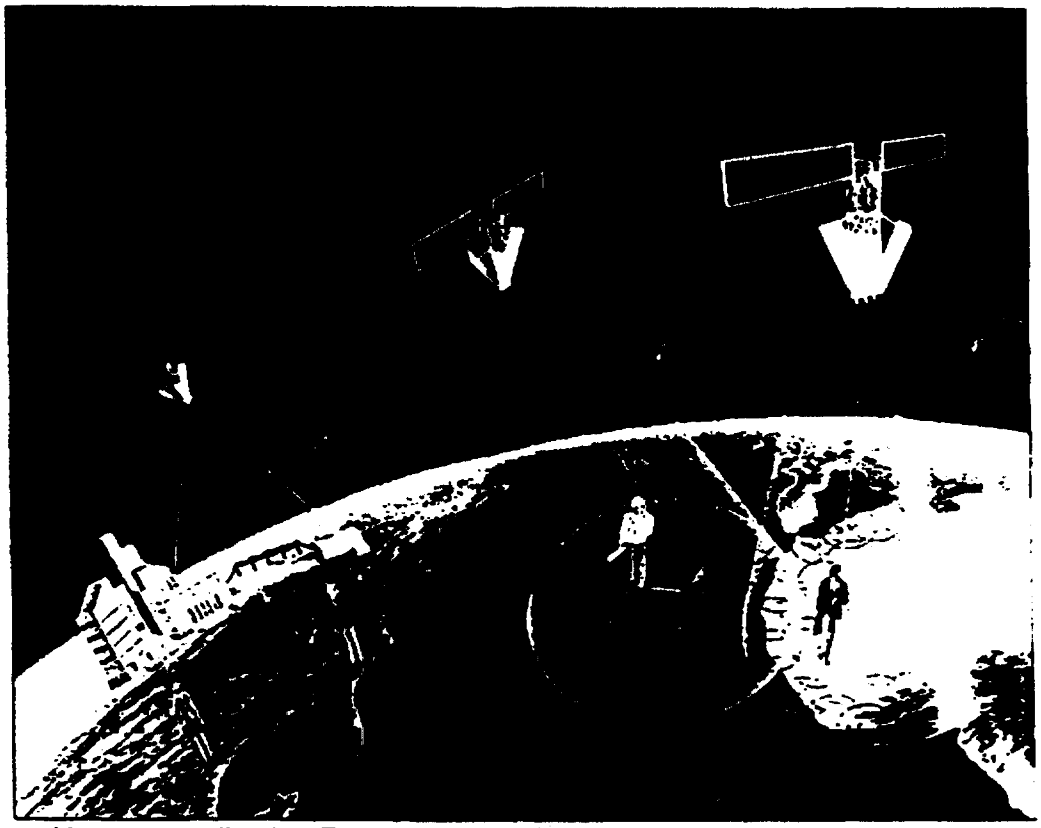
To make up the shortfall, the cellular industry is starting to target the mass market. But while this has boosted subscriber numbers, it has also resulted in sharply higher costs. Cellular operators are discovering that selling to the mass market means more advertising, new sales channels (such as high-street retailers and mail-order catalogues) and big handset subsidies. Worse, each new generation of cellphone user tends to be more thrifty than the last. Some analysts think cellular operators will be lucky to see $50 of call revenues a month by the middle of this decade.

Blurred marketing is not helping. While one half of the industry is trying to woo the mass market with traditional analogue or digital cellular services, the other half is telling consumers that what they really need is an entirely new sort of mobile telephone—the personal communications service. The thinking behind PCS is simple. Halve the cost of calls, make the handsets cheap, small and simple, and consumers will start using them just like wired telephones—ie, a lot, and in their tens of millions. Tantalisingly, this promises to open up a vast new telecoms market: 96% of 1992's $400 billion in global telephone-service revenues was generated by wired operators.

PCS is no panacea, however. First, a PCS network is costly to build—and for traditional cellular operators that expense comes on top of the cost of upgrading existing analogue networks to digital, at a time when profits are already being squeezed. Second, both cellular and wired operators hoping to build PCS networks face the prospect of losing some existing customers to the new services. As Columbia University's Mr Noam puts it, "If one develops new routes of communication, old ones atrophy. Just look at what happened to Venice after Columbus and Vasco da Gama."

To make the most of those new routes, the industry must undergo radical change. The fragmented, highly competitive wireless-communications market of tomorrow will be no place for firms accustomed, at worst, to duopoly. Many of today's unprofitable and indebted cellular operators will face a stark choice: ally, merge or go bust. A similar fate awaits many PCS pioneers. Alone, few will have the financial staying-power to make the technology profitable.

The strongest players will be those who see the new wireless technologies not as a complement to their existing services, but as a way to conquer new territory—the local-loop monopolies of rival or overseas telephone companies, the hegemony of broadcast and cable-TV firms, the market for on-the-move information. These, in turn, will demand their own alliances: Time Warner's multimedia products will be delivered over US West's PCS network to Apple's fourth-generation Newton. The prospect of so many corporate couplings is apt, perhaps, for an industry whose big selling point is that it brings its customers closer together. But having whet those customers' appetites with the wonders of wireless, there is no going back.



I told you not to call at the office

VIDEO
New York, NY

MONTHLY 473,128

OCT 1993

M17834

LUCE PRESS CLIPPINGS

The littlest dish

►► Just when you've decided where you're going to buy that 18-inch satellite dish when DBS comes on the market next spring, along comes another dish service touting an even smaller antenna, this one about the size and shape of a standard CD jewel box. Cellularvision of New York, which has been testing its new system for about a year in the Brighton Beach section of Brooklyn, New York, recently announced it has joined forces with Bell Atlantic, which will invest in the company and operate the system.

Cellularvision's technology uses super-high-frequency transmission to deliver signals to a five-inch, flat-plate, window-mounted antenna. The service operates at 28 gigahertz, and the company claims it dramatically improves broadcast picture and sound clarity without compression because it uses FM rather than AM transmission. It is also designed to deliver a full complement of voice, data, video and interactive services in the future, company officials said. The FCC is expected to allow nationwide use of the frequency for these purposes sometime next year.

Show and Tell: Bernard Bossard, Cellularvision's chief engineering officer, displays his mini-dish.

Cellularvision CEO Shant Hovnanian said that because the service doesn't need a direct line of sight from each mini-dish to the transmitter, it should be especially attractive to viewers in densely populated urban areas.

—Jim Barry

Investor's Business Daily

August 12, 1993

Will Cell Approach To Interactive Services Deliver Quality At Low Cost?

By Michael Stroud
In Los Angeles

Visionaries long have predicted interactive television would revolutionize home entertainment and business.

☑ Computers & Automation

By stringing fiber-optic cable to viewers' homes or workplaces, pundits say, the public will be able to access hundreds of TV channels, tap information services, conduct financial transactions and hold two-way videoconferences.

A key problem has been cost. Media giants Time Warner Inc. and Tele-Communications Inc. are spending billions of dollars to lay fiber. Customers ultimately will absorb that cost in their cable bills.

Last week, Bell Atlantic Corp. announced a partnership with a small private company called CellularVision of New York Inc. to pursue a radically different interactive TV approach in the New York area. The partners claim their system will cut costs substantially.

Instead of cable, the companies will transmit microwave signals through a network of cells similar to those employed by cellular phones. A television viewer will receive the signal on a small antenna mounted on a window. A cable will run from the antenna to the viewer's television set.

Reduced installation and maintenance costs already allow CellularVision to offer 41 cable television channels with wireless technology to 200 families in the New York suburb of Brighton Beach at 60% of the price of competing cable services, according to Shant Hovnanian, the company's chief executive.

The technology "solves a lot of the questions about how to get broad-band (video) services to the home affordably," Hovnanian said.

Bell Atlantic will operate and deploy the network of cells, which the companies plan to set up over the next year in five New York boroughs and nearby counties. Bell Atlantic also has taken a minority stake of undisclosed size in CellularVision.

CellularVision's technology eventually could compete with conventional telephone and data services.

'An Unproven Technology'

Cable companies aren't willing to throw in the towel.

Mike Luftman, a spokesman for Time Warner's cable unit, calls CellularVision's wireless approach "an unproven technology."

Luftman says images broadcast using CellularVision's technology are sometimes muddy. And he challenges Hovnanian's assertion that a microwave signal can carry as much data as an advanced cable line.

"They can overlook a lot of things, but they can't overlook the laws of physics," he said.

Time Warner already has an experimental cable service in New York offering far more channels than ordinary cable television. The company also is developing a fiber-optic system offering hundreds of channels in Orlando, Fla. The system will be the prototype for future Time Warner services nationwide.

Hovnanian insists the wireless system can handle the hundreds of channels that cable operators like Time Warner are planning for their customers. And he says the picture quality and reliability of his service matches or surpasses anything that cable operators offer.

During a recent Brighton storm, he observes, cable customers temporarily lost their service.

"We were the only ones left operating," he said.

Wireless "cable" is not a new concept. But supporters of the idea have been stymied by the tendency of high-frequency signals from nearby cells to overlap and interfere with each other.

CellularVision has a patented technology that it claims overcomes the problem. The technology was invented by Bernard Bossard, a CellularVision co-founder who is currently its chief engineering officer.

Ordinary cellular phones operate below the one gigahertz spectrum range. CellularVision's system operates at the superhigh 28 gigahertz range.

The Federal Communications Commission has granted the company a license in the New York area. The company says the FCC is expected to license the spectrum nationwide in coming months.

If the service rollout in New York is a success, CellularVision plans to expand into other markets.

Potential Customers

Hovnanian says CellularVision hopes to link different regions through interfaces with satellites and existing fiber-optic lines.

While home customers will be a strong focus of early marketing efforts, Hovnanian also is trying to stimulate interest among potential business customers.

CellularVision plans to test its product on Wall Street over the next year as an alternative to telecommunication services provided over fiber-optic cable. Teleconferencing, which the company already has demonstrated in Brighton Beach trials, is one potential early use.

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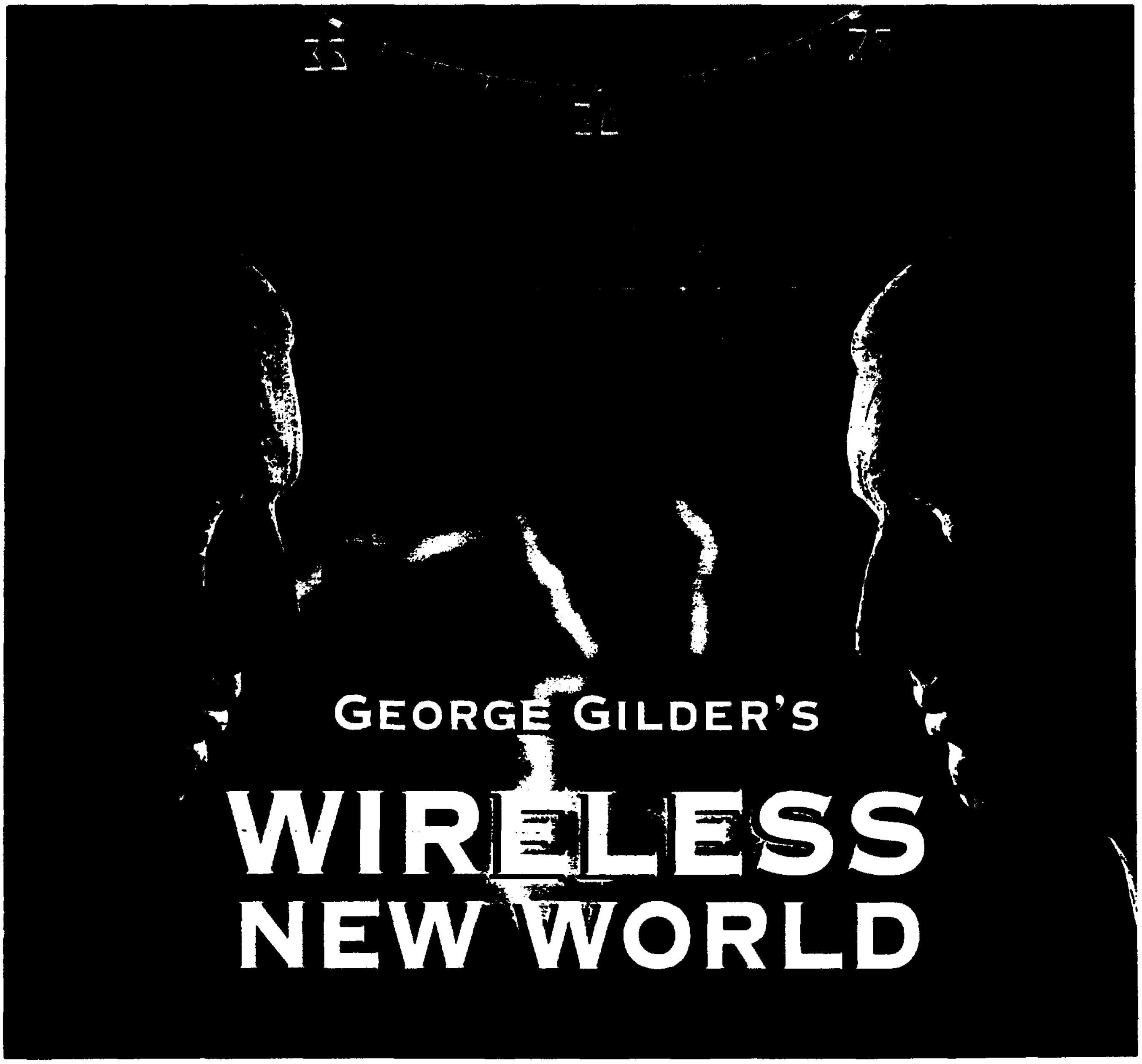

GEORGE GILDER'S

TELECOSM

"The New Rule of Wireless"

AT FIRST GLANCE, Vahak Hovnanian, a homebuilding tycoon in New Jersey, would seem an unlikely sort to be chasing rainbows. Yet in the converging realms of computers and communications that we call the telecosm, rainbows are less a matter of hue and weather than they are a metaphor for electromagnetism: the spectrum of wavelengths and frequencies used to build businesses in the Information Age.

An Armenian Christian from Iraq, Hovnanian ran a business building high-quality "affordable" housing. His first coup came on Labor Day in 1958 when, together with his three older brothers, he bought an apparently undesirable property near the waterfront in Tom's River for $20,000. From this modest beginning has arisen not only one of the nation's largest homebuilding enterprises (divided among the four immigrant brothers), but also a shattering breakthrough on some seemingly bleak frontiers of the electromagnetic spectrum. Together with maverick inventor Bernard Bossard, Hovnanian has launched a wireless cellular TV business in frequencies once thought usable only in outer space.

Perhaps the reason Hovnanian feels comfortable today pioneering on the shores of the telecosm is that some 35 years ago he was an engineer at Philco Semiconductor following in the theoretical steps of AT&T Bell Laboratories titan William Shockley. Shockley led the team that plunged into the microcosm of solid-state physics and invented the transistor. At the heart of all-digital electronics, this invention still reverberates through the world economy and imposes its centrifugal rules of enterprise.

This law of the microcosm dictates exponential rises in computer efficiency as transistors become smaller. It is this law that drives the bulk of the world's computations to ever-cheaper machines and pushes intelligence from the center to the fringes of all networks. Today the microcosm is converging with the telecosm and igniting a new series of industrial shocks and surprises.

The convergence of microcosm and telecosm in an array of multimedia industries—from personal intelligent communicators to video teleputers to digital films and publishing—is now the driving force of world economic growth. John Sculley, chairman and CEO of Apple Computer, has projected that by 2002 there will be a global business in multimedia totaling some $3.5 trillion—close to the size of the entire U.S. economy in the early 1980s.

This new world of computer communications will break down into two domains—the fibersphere and the atmosphere. The fibersphere is the domain of all-optical networks, with both communications power—bandwidth—and error rate improving by factors in the millions. In "Into the Fibersphere" (Forbes *ASAP*, December 7, 1992), we saw that the potential capacity for communications in the fibersphere is 1,000 times greater than all the currently used frequencies in the air—and so radically error-free that it mandates an entirely new model of wired telecommunications. Now we will discover that the atmosphere will offer links as mobile and ubiquitous as human beings are. It thus will force the creation of an entirely new model of wireless networks.

In one sense, Sculley's $3.5 trillion dream can be seen as the pot of gold at the end of Maxwell's rainbow. In 1865, in a visionary coup that the late Richard Feynman said would leave the American Civil War of the same decade as a mere "parochial footnote" by comparison, Scottish physicist James Clerk Maxwell discovered the electromagnetic spectrum. Encompassing nearly all the technologies imagined by Sculley, Maxwell's rainbow reaches from the extremely low frequencies (and gigantic wavelengths) used to communicate with submarines all the way through the frequencies used in radio, television and cellular phones, on up to the frequencies of infrared used in TV remotes and fiber optics, and beyond that to visible and ultraviolet light and X-rays. In a fabulous feat of unification, Maxwell reduced the entire spectrum to just four equations in vector calculus. He showed that all such radiations move at the speed of light—in other words, the wavelength times the frequency equals the speed of light. These equations pulse at the heart of the information economy today.

Virtually all electromagnetic radiation can bear information, and the higher the frequencies, the more room they provide for bearing information. As a practical matter, however, communications engineers have aimed low, thronging the frequencies at the bottom of the spectrum, comprising far less than one percent of the total span.

The vast expansion of wireless communications forecast by Sculley, however, will require the use of higher frequencies far up Maxwell's rainbow. This means a return to the insights of another great man who walked the halls of Bell Labs in the late 1940s at the same time as future Nobel laureate William Shockley, and who left the world transformed in his wake.

In 1948, the same year that Shockley invented the transistor, Claude Shannon invented the information theory that underlies all modern communications. At first encounter, information theory is difficult for nonmathematicians, but computer and telecom executives need focus on only a few key themes. In defining how much information can be sent down a noisy channel, Shannon showed that engineers can choose between narrowband high-powered solutions and broadband low-powered solutions.

> *Such an explosion of efficiency radically limits the need to waste watts in order to overcome noise. More communication power comes from less electrical power. Thus, Shannon shows the way to Sculley's vision.*

From Long & Strong to Wide & Weak

Assuming that usable bandwidth is scarce and expensive, most wireless engineers have strived to economize on it. Just as you can get your message through in a crowded room by talking louder, you can overcome a noisy channel with more powerful signals. Engineers therefore have pursued a strategy of long and strong: long wavelengths and powerful transmissions with the scarce radio frequencies at the bottom of the spectrum.

Economizing on spectrum, scientists created mostly analog systems such as AM radios and televisions. Using every point on the wave to convey information and using high power to overcome noise and extend the range of signals, the long and strong approach seemed hugely more efficient than digital systems requiring complex manipulation of long strings of on-off bits.

Ironically, however, the long and strong policy of economizing on spectrum led to using it all up. When everyone talks louder, no one can hear very well. Today, the favored regions at the bottom of the spectrum are so full of spectrum-hogging radios, pagers, phones, television, long-distance, point-to-point, aerospace and other uses that heavy-breathing experts speak of running out of "air."

Shannon's theories reveal the way out of this problem. In a counterintuitive and initially baffling redefinition of the nature of noise in a communications channel, Shannon showed that a flow of signals conveys information only to the extent that it provides unexpected data—only to the extent that it adds to what you already know. Another name for a stream of unexpected bits is noise. Termed Gaussian, or white, noise, such a transmission resembles random "white" light, which cloaks the entire rainbow of colors in a bright blur. Shannon showed that the more a transmission resembles this form of noise, the more information it can hold.

Shannon's alternative to long and strong is wide and weak: not fighting noise with electrical power but joining it with noiselike information, not talking louder but talking softer in more elaborate codes using more bandwidth. For example, in transmitting 40 megabits per second—the requirement for truly high-resolution images and sounds—Shannon showed some 45 years ago that using more bandwidth can lower the needed signal-to-noise ratio from a level of one million to one to a ratio of 30.6 to one. This huge gain comes merely from increasing the bandwidth of the signal from two megahertz (millions of cycles per second) to eight megahertz. That means a 33,000-fold increase in communications efficiency in exchange for just a fourfold increase in bandwidth.

Such an explosion of efficiency radically limits the need to waste watts in order to overcome noise. More communications power comes from less electrical power. Thus, Shannon shows the way to fulfill Sculley's vision of universal low-powered wireless communications.

This vision of wide and weak is at the heart of the most promising technologies of today, from the advanced digital teleputer sets of American HDTV to ubiquitous mobile phones and computers in so-called personal communications networks (PCNs). Shannon's theories of the telecosm provide the basic science behind both Sculley's dream and Hovnanian's video spectrum breakthrough.

Shannon's world, however, is not nirvana, and there is no free lunch. Compensating for the exponential rise in communications power is an exponential rise in complexity. Larger bandwidths mean larger, more complex codes and exponentially rising burdens of computation for the decoding and error-correcting of messages. In previous decades, handling 40 megabits per second was simply out of the question with existing computer technology. For the last 30 years, this electronic bottleneck has blocked the vistas of efficient communication opened by Shannon's research.

In the 1990s, however, the problem of soaring complexity has met its match—and then some—in exponential gains of computer efficiency. Not only has the cost-effectiveness of microchip technology been doubling every 18 months but the pace of advance has been accelerating into the 1990s. Moreover, the chips central to digital communications—error correction, compression, coding and decoding—are digital signal processors. As we have seen, the cost-effectiveness of DSPs has been increasing—in millions of computer instructions per second (MIPS) per dollar—some tenfold every two years.

This wild rush in DSPs will eventually converge with the precipitous plunge in price-performance ratios of general-purpose microprocessors. Led by Silicon Graphics' impending new TFP Cray supercomputer on a chip, Digital Equipment's Alpha AXP device and Hewlett Packard's Precision Architecture 7100, micros are moving beyond 100-megahertz clock rates. They are shifting from a regime of processing 32-bit words at a time to a regime of processing 64-bit words. This expands the total addressable memory by a factor of four billion. Together with increasing use of massively parallel DSP architectures, these gains will keep computers well ahead of the complexity problem in broadband communications.

What this means is that while complexity rises exponentially with bandwidth, computer efficiencies are rising even faster. The result is to open new vistas of spectrum in the atmosphere as dramatic as the gains of spectrum so far achieved in the fibersphere.

ATTACKING THROUGH THE AIR

Hovnanian's campaign into the spectrum began when a cable company announced one day in 1985 that under the Cable Act of 1984 and franchise rights granted by local governments, it had the right to wire one of his housing developments then under construction. Until that day, Hovnanian's own company could package cable with his homes through what are called satellite master antenna TV systems. In essence, each Hovnanian development had its own cable head end where programs are collected and sent out to subscribers.

Air delivery of cable television programming had long seemed unpromising. Not only was there too little spectrum available to compete with cable, but what spectrum there was, was guarded by the FCC.

When the cable company, now Monmouth Cable Vision, went to court and its claim was upheld by a judge, Hovnanian sought alternatives. First he flirted with the idea of having the phone company deliver compressed video to his homes. In 1986, in the era before FCC Commissioner Alfred Sikes, that was both illegal and impractical. Then he met Bernard Bossard and decided to attack through the air. An early pioneer in microchips who had launched a semiconductor firm and eventually sold it to M/A COM, Bossard was familiar with both the soaring power of computers and the murky problems of broadband noise that have long restricted the air to a small number of broadcast AM TV stations.

Air delivery of cable television programming had long seemed unpromising. Not only was there too little spectrum available to compete with cable, but what spectrum there was, was guarded by the FCC and state public utilities commissions.

Nonetheless, in the early 1990s "wireless cable" did become a niche market, led by Microband Wireless Cable and rivals and imitators across the land. Using fragments of a frequency band between 2.5 and 2.7 gigahertz (billions of cycles per second), Microband, after some financial turmoil, now profitably broadcasts some 16 channels to 35,000 New York City homes in line of sight from the top of the Empire State Building. As long as they are restricted to a possible maximum of 200 megahertz and use AM, however, wireless firms will not long be able to compete with the cable industry. Cable companies offer an installed base of potential gigahertz connections and near universal coverage.

Having spent much of his life working with microwaves for satellites and the military, Bossard had a better idea. He claimed he could move up the spectrum and pioneer on frontiers of frequency between 27.5 and 29.5 gigahertz, previously used chiefly in outer space. That would mean he could command in the air some half a million times the communications power, or bandwidth, of typical copper telephone links, some ten times the bandwidth of existing wireless cable, some four times the bandwidth of the average cable industry coaxial connection, and twice the bandwidth of the most advanced cable systems.

The conventional wisdom was that these microwaves (above about 12 gigahertz) are useless for anything but point-to-point transmissions and are doubtful even for these. For radio communication, the prevailing folklore preferred frequencies that are cheap to transmit long distances and that can penetrate buildings and tunnels, bounce off the ionosphere or scuttle across continents along the surface of the earth. The higher the frequency, the less it can perform these feats essential to all broadcasting—and the less it can be sent long distances at all.

Moreover, it was believed, these millimeter-sized microwaves not only would fail to penetrate structures and other obstacles but would reflect off them and off particles in the air in a way that would cause hopeless mazes of multipath. Multipath would be translated into several images, i.e., ghosts, on the screen.

Finally, there was the real show-stopper. Everyone knew that these frequencies are microwaves. The key property of microwaves, as demonstrated in the now ubiquitous ovens, is absorption by water. Microwaves cook by exciting water molecules to a boil. Microwave towers are said to kill birds by irradiating their fluids. Microwave radar systems won't work in the rain. Mention microwaves as a possible solution to the spectrum shortage, and everyone—from editors at *Forbes* to gurus at Microsoft, from cable executives to Bell Labs researchers—laughs and tells you about the moisture problem.

So it was no surprise that when in 1986 Bossard went to M/A COM and other companies and financiers with his idea of TV broadcasting at 28 gigahertz, he was turned down flat. Amid much talk of potential "violations of the laws of physics," jokes about broiling pigeons and warnings of likely resistance from the FCC, he was spurned by all. In fairness to his detractors, Bossard had no license, patent or prototype at the time. But these holes in his plan did not deter Vahak Hovnanian and his son Shant from investing many millions of dollars in the project. It could be the best investment the Hovnanian tycoons ever made.

> *The new rule of radio is the shorter the transmission path, the better the system. Like transistors on semiconductor chips, transmitters are more efficient the more closely they are packed together.*

New Rule of Radio

For 35 years, the wireless communications industry has been inching up the spectrum, shifting slowly from long and strong wavelengths toward wide and weak bands of shorter wavelengths. Mobile phone services have moved from the 1950s radio systems using low FM frequencies near 100 megahertz, to the 1960s spectrum band of 450 megahertz, to the current cellular band of 900 megahertz accommodating more than 10 million cellular subscribers in the U.S.

During the 1990s, this trend will accelerate sharply. Accommodating hundreds of millions of users around the world, cellular communications will turn digital, leap up the spectrum and even move into video. Shannon's laws show that this will impel vast increases in the cost-effectiveness of communications.

In general, the new rule of radio is the shorter the transmission path, the better the system. Like transistors on semiconductor chips, transmitters are more efficient the more closely they are packed together. As Peter Huber writes in his masterly new book, *The Geodesic Network 2*, the new regime favors "geodesic networks," with radios intimately linked in tiny microcells. As in the law of the microcosm, the less the space, the more the room.

This rule turns the conventional wisdom of microwaves upside down. For example, it is true that microwaves don't travel far in the atmosphere. You don't want to use them to transmit 50,000 watts of Rush Limbaugh over 10 midwestern states, but to accommodate 200 million two-way communicators will require small cells; you don't want the waves to travel far. It is true that microwaves will not penetrate most buildings and other obstacles, but with lots of small cells, you don't want the waves to penetrate walls to adjacent offices.

Microwaves require high-power systems to transmit, but only if you want to send them long distances. Wattage at the receiver drops off in proportion to the fourth power of the distance from the transmitter. Reducing cell sizes as you move up the spectrum lowers power needs far more than higher frequencies increase them. Just as important, mobile systems must be small and light. The higher the frequency, the smaller the antenna and the lighter the system can be.

All this high-frequency gear once was prohibitively expensive. Any functions over two gigahertz require gallium arsenide chips, which are complex and costly. Yet the cost of gallium arsenide devices is dropping every day as their market expands. Meanwhile, laboratory teams are now tweaking microwaves out of silicon. In the world of electronics—where prices drop by a third with every doubling of accumulated sales—any ubiquitous product will soon be cheap.

The law of the telecosm dictates that the higher the frequency, the shorter the wavelength, the wider the bandwidth, the smaller the antenna, the slimmer the cell and ultimately, the cheaper and better the communication. The working of this law will render obsolete the entire idea of scarce spectrum and launch an era of advances in telecommunications comparable to the recent gains in computing. Transforming the computer and phone industries, the converging spirits of Maxwell, Shannon and Shockley even pose a serious challenge to the current revolutionaries in cellular telephony.

Digital signal processors are increasing their cost-effectiveness tenfold every two years. As Donald Steinbrecher says, "That changes wireless from a radio business to a computer business."

THE NEW PC REVOLUTION: PCN

Many observers herald the huge coming impact of wireless on the computer industry, and they are right. But this impact will be dwarfed by the impact of computers on wireless.

In personal communications networks (PCN), the cellular industry today is about to experience its own personal computer revolution. Just as the personal computer led to systems thousands of times more efficient in MIPS per dollar than the mainframes and minicomputers that preceded it, PCNs will bring an exponential plunge of costs. These networks will be based on microcells often measured in hundreds of meters rather than in tens of miles and will interlink smart digital appliances, draining power in milliwatts rather than dumb phones using watts. When the convulsion ends later this decade, this new digital cellular phone will stand as the world's most pervasive PC. As mobile as a watch and as personal as a wallet, these PICOs will recognize speech, navigate streets, take notes, keep schedules, collect mail, manage money, open the door and start the car, among other computer functions we cannot imagine today.

Like the computer establishment before it, current cellular providers often seem unprepared for this next computer revolution. They still live in a world of long and strong—high-powered systems at relatively low frequencies and with short-lived batteries—rather than in a PCN world of low-power systems at microwave frequencies and with batteries that last for days.

Ready or not, though, the revolution will happen anyway, and it will transform the landscape over the next five years. We can guess the pattern by considering the precedents. In computers, the revolution took 10 years. It began in 1977 when large centralized systems with attached dumb terminals commanded nearly 100 percent of the world's computer power and ended in 1987 with such large systems commanding less than one percent of the world's computer power. The pace of progress in digital electronics has accelerated sharply since the early 1980s. Remember yesterday, when digital signal processing (DSP)—the use of specialized computers to convert, compress, shape and shuffle digital signals in real time—constituted an exorbitant million-dollar obstacle to all-digital communications? Many current attitudes toward wireless stem from that time, which was some five years ago. Today, digital signal processors are the fastest-moving technology in all computing. Made on single chips or multichip modules, DSPs are increasing their cost-effectiveness tenfold every two years. As radio pioneer Donald Steinbrecher says, "That changes wireless from a radio business to a computer business."

Thus, we can expect the cellular telephone establishment to reach a crisis more quickly than the mainframe establishment did. The existing cellular infrastructure will persist for vehicular use.

As the intelligence in networks migrates to microcells, the networks themselves must become dumb. A complex network, loaded up with millions of lines of software code, cannot keep up with the efflorescent diversity and creativity among ever more intelligent digital devices on its periphery. This rule is true for the broadband wire links of fiber optics, as intelligent switching systems give way to passive all-optical networks. It is also true of cellular systems.

Nick Kauser, McCaw Cellular Communications' executive vice-president and chief of technology, faced this problem early in 1991 when the company decided to create a North American Cellular Network for transparent roaming throughout the regions of Cellular One. "The manufacturers always want to sell switches that do more and more. But complex switches take so long to program that you end up doing less and less," says Wayne Perry, McCaw vice-chairman. Each time Kauser tried to change software code in one of McCaw's Ericsson switches, it might have taken six months. Each time he wanted to add customer names above a 64,000 limit, Ericsson tried to persuade him to buy a new switch. The Ericsson switches, commented one McCaw engineer, offer a huge engine but a tiny gas tank. The problem is not peculiar to Ericsson, however; it is basic to the very idea of complex switch-based services on any supplier's equipment.

When McCaw voiced frustration, one of the regional Bell operating companies offered to take over the entire problem at a cost of some $200 million. Instead, Kauser created a Signaling System 7 (SS-7) network plus an intelligent database on four Tandem fault-tolerant computers, for some $15 million. Kauser maintains that the current services offered by North American Cellular could not be duplicated for 10 times that amount, if at all, in a switch-based system. Creating a dumb network and off-loading the intelligence on computer servers saved McCaw hundreds of millions of dollars.

The law of the microcosm is a centrifuge, inexorably pushing intelligence to the edges of networks. Telecom equipment suppliers can no more trap it in the central switch than IBM could monopolize it in mainframes.

Kauser should recognize that this rule applies to McCaw no less than to Ericsson. His large standardized systems with 30-mile cells and relatively dumb, high-powered phones resemble big proprietary mainframe networks. In the computer industry, these standardized architectures gave way to a mad proliferation of diverse personal computer nets restricted to small areas and interlinked by hubs and routers. The same pattern will develop in cellular.

COULD 'CHARLES' UPEND MCCAW?

Together with GTE and the regional Bell operating company cellular divisions, McCaw is now in the position of DEC in 1977. With its new ally, AT&T, McCaw is brilliantly attacking the mainframe establishment of the wire-line phone companies. But the mainframe establishment of wires is not McCaw's real competition. Not stopping at central switches, the law of the microcosm is about to subvert the foundations of conventional cellular technology as well. Unless McCaw and the other cellular providers come to terms with the new PC networks that go by the name of PCNs, they will soon suffer the fate of the minicomputer firms of the last decade. McCaw could well be upended by its founder's original vision of his company—a PICO he called "Charles."

Just as in the computer industry in the late 1970s, the fight for the future is already under way. Complicating the conflict is the influence of European and Japanese forces protecting the past in the name of progress. Under pressure from EEC industrial politicians working with the guidance of engineers from Ericsson, the Europeans have adopted a new digital cellular system called Groupe Speciale Mobile (GSM) after the commission that conceived it. GSM is a very conservative digital system that multiplies the number of users in each cellular channel by a factor of three.

GSM uses an access method called time-division multiple access (TDMA). Suggestive of the time-sharing methods used by minicomputers and mainframes to accommodate large numbers of users on centralized computers, TDMA stems from the time-division multiplexing employed by phone companies around the world to put more than one phone call on each digital line. Thus, both the telephone and the computer establishments are comfortable with time division.

Under pressure from European firms eager to sell equipment in America, the U.S. Telephone Industry Association two years ago adopted a TDMA standard similar to the European GSM. Rather than creating a wholly new system exploiting the distributed powers of the computer revolution, the TIA favored a TDMA overlay on the existing analog infrastructure. Under the influence of Ericsson, McCaw and some of the RBOCs took the TDMA bait.

Thus, it was in the name of competitiveness and technological progress, and of keeping up with the Europeans and Japanese, that the U.S. moved to embrace an obsolescent cellular system. It made no difference that the Europeans and Japanese were technologically well in our wake. Just as in the earlier case of analog HDTV, however, the entrepreneurial creativity of the U.S. digital electronics industry is launching an array of compelling alternatives just in time.

Infusing cellular telephony with the full powers of wide and weak—combining Shannon's vision with computer advances—are two groups of engineers from MIT who spun out to launch new companies. Qualcomm Inc. of San Diego is led by former professor Irwin Jacobs and telecom pioneer Andrew Viterbi. A Shannon disciple whose eponymous algorithm is widely used in digital wire-line telephony, Viterbi now is leading an effort to transform digital wireless telephony. The other firm, Steinbrecher Corp., of Woburn, Mass., is led by an inventor from the MIT Radio Astronomy Lab named Donald Steinbrecher.

Like Bernie Bossard and Vahak Hovnanian, the leaders of Qualcomm and Steinbrecher received the ultimate accolade for an innovator: They were all told their breakthroughs were impossible. Indeed, the leaders at Qualcomm were still contending that Steinbrecher's system would not work just weeks ago when PacTel pushed the two firms together. Now they provide the foundations for a radical new regime in distributed wireless computer telephony.

SIGNALS IN PSEUDONOISE

Ten years ago at Linkabit, the current leaders of Qualcomm conceived and patented the TDMA technology adopted as the U.S. standard by the Telephone Industry Association. Like analog HDTV, it was a powerful advance for its time. But even then, Viterbi and Jacobs were experimenting with a Shannonesque technology.

A classic example of the efficacy of wide and weak, CDMA exploits the resemblance between noise and information. The system began in the military as an effort to avoid jamming or air-tapping of combat messages. Qualcomm brings CDMA to the challenge of communications on the battlefronts of big-city cellular.

Rather than compressing each call into between three and 10 tiny TDMA time slots in a 30-kilohertz cellular channel, Qualcomm's CDMA spreads a signal across a comparatively huge 1.25-megahertz swath of the cellular spectrum. This allows many users to share the same spectrum space at one time. Each phone is programmed with a specific pseudonoise code, which is used to stretch a low-powered signal over a wide frequency band. The base station uses the same code in inverted form to "despread" and reconstitute the original signal. All other codes remain spread out, indistinguishable from background noise.

> *Thus, it was in the name of competitiveness and technological progress, and of keeping up with the Europeans and Japanese, that the U.S. moved to embrace an obsolescent cellular system.*

Jacobs compares TDMA and CDMA to different strategies of communication at a cocktail party. In the TDMA analogy, each person would restrict his or her talk to a specific time slot while everyone else remains silent. This system would work well as long as the party was managed by a dictator who controlled all conversations by complex rules and a rigid clock. In CDMA, on the other hand, everyone can talk at once but in different languages. Each person listens for messages in his or her own language or code and ignores all other sounds as background noise. Although this system allows each person to speak freely, it requires constant control of the volume of the speakers. A speaker who begins yelling can drown out surrounding messages and drastically reduce the total number of conversations that can be sustained.

For years, this problem of the stentorian guest crippled CDMA as a method of increasing the capacity of cellular systems. Spread spectrum had many military uses because its unlocalized signal and cryptic codes made it very difficult to jam or overhear. In a cellular environment, however, where cars continually move in and out from behind trucks, buildings and other obstacles, causing huge variations in power, CDMA systems would be regularly swamped by stentorian guests. Similarly, nearby cars would tend to dominate faraway vehicles. This was termed the near-far problem. When you compound this challenge with a static of multipath signals causing hundreds of 10,000-to-1 gyrations in power for every foot traveled by the mobile unit—so-called Rayleigh interference pits and spikes—you can comprehend the general incredulity toward CDMA among cellular cognoscenti. Indeed, as recently as 1991, leading experts at Bell Labs, Stanford University and Bellcore confidently told me the problem was a show-stopper; it could not be overcome.

Radio experts, however, underestimate the power of the microcosm. Using digital signal processing, error correction and other microcosmic tools, wattage spikes and pits 100 times a second can be regulated by electronic circuitry that adjusts the power at a rate of more than 800 times a second.

To achieve this result, Qualcomm uses two layers of controls. First is a relatively crude top layer that employs the automatic gain control device on handsets to constantly adjust the power sent by the handset to the level of power received by it from the base station. This rough adjustment does not come near to solving the problem, but it brings a solution into reach by using more complex and refined techniques.

In the second power-control step, the base station measures the handset's signal-to-noise and bit-error ratios once every 1.25 milliseconds (800 times a second). Depending on whether these ratios are above or below a constantly recomputed threshold, the base station sends a positive or negative pulse, either raising or lowering the power some 25 percent.

Dynamic Cells

Passing elaborate field tests with flying colors, this power-control mechanism has the further effect of dynamically changing the size of cells. In a congested cell, the power of all phones rises to overcome mutual interference. On the margin, these high-powered transmissions overflow into neighboring cells where they may be picked up by adjacent base station equipment. In a quiet cell, power is so low that the cell effectively shrinks, transmitting no interference at all to neighboring cells and improving their performance. This kind of dynamic adjustment of cell sizes is impossible in a TDMA system, where adjacent cells use completely different frequencies and fringe handsets may begin to chirp like Elmer Fudd.

Once the stentorian voice could be instantly abated, power control changed from a crippling weakness of CDMA into a commanding asset. Power usage is a major obstacle to the PCN future. All market tests show that either heavy or short-lived batteries greatly reduce the attractiveness of the system. Because the Qualcomm feedback system keeps power always at the lowest feasible level, batteries in CDMA phones actually are lasting far longer than in TDMA phones. CDMA phones transmit at an average of two milliwatts, compared with 600 milliwatts and higher for most other cellular systems.

A further advantage of wide and weak comes in handling multipath signals, which bounce off obstacles and arrive at different times at the receiver. Multipath just adds to the accuracy of CDMA. The Qualcomm system combines the three strongest signals into one. Called a rake receiver and co-invented by Paul Green, currently at IBM and author of *Fiber Optic Networks* (Prentice Hall, 1992), this combining function works even on signals from different cells and thus facilitates hand-offs. In TDMA, signals arriving at the wrong time are pure interference in someone else's time slot; in CDMA, they strengthen the message.

A further advantage of wide and weak comes in handling multipath signals, which bounce off obstacles and arrive at different times at the receiver. Multipath just adds to the accuracy of CDMA.

Finally, CDMA allows simple and soft hand-offs. Because all the phones are using the same spectrum space, moving from one cell to another is easy. CDMA avoids all the frequency juggling of TDMA systems as they shuffle calls among cells and time slots. As the era of PCN microcells approaches, this advantage will become increasingly crucial. Cellular systems that spurn Qualcomm today may find themselves in a quagmire of TDMA microcells tomorrow. Together, all the gains from CDMA bring about a tenfold increase over current analog capacity. In wireless telephony above all, wide and weak will prevail.

Like any obsolescent scheme challenged by a real innovation—and like minicomputers and mainframes challenged by the PC—TDMA is being sharply improved by its proponents. The inheritors of the Linkabit TDMA patents at Hughes and International Mobile Machines Corp. (IMMC) have introduced extended TDMA, claiming a 19-fold advance over current analog capacity. Showing a conventional cellular outlook, however, E-TDMA fatally adopts the idea of increasing capacity by lowering speech quality. This moves in exactly the wrong direction. PCN will not triumph through compromises based on a scarce-spectrum mentality. PCN will multiply bandwidth to make the acoustics of digital cellular even better than the acoustics of wire-line phones, just as the acoustics of digital CDs far excel the acoustics of analog records.

Riding the microcosmic gains of digital signal processing, CDMA inherently offers greater room for improvement than TDMA does. Bringing the computer revolution to cellular telephony, CDMA at its essence replaces frequency shuffling with digital intelligence. Supplanting the multiple radios of TDMA—each with a fixed frequency—are digital-signal-processing chips that find a particular message across a wide spectrum swath captured by one broadband radio.

With the advance in digital electronics, the advantage of CDMA continually increases. As the most compute-intensive system, CDMA gains most from the onrushing increases in the cost-effectiveness of semiconductor electronics. Qualcomm recently announced that it has reduced all the digital signal processing for CDMA into one application-specific chip.

For all the indispensable advances of CDMA, however, Qualcomm cannot prevail alone. It brilliantly executes the move to digital codes, but proprietary mainframe computer networks are digital, too. As presently conceived, CDMA still aspires to be a cellular standard using the same mainframe architecture of mobile telephone switching offices that now serve the analog cellular system. In itself the Qualcomm solution does little to move cellular toward the ever cheaper, smaller and more open architectures that now dominate network computing and will shape PCN.

Hearing Feathers Crash Amid Heavy Metal

Consummating the PCN revolution—with its millions of microcells around the globe and its myriad digital devices and frequencies—will require a fundamental breakthrough in cellular radio technology. In the new Steinbrecher minicell introduced early this month at the Cellular Telephone Industry Association show, that breakthrough is at hand. The first true PC server for PCN, this small box ultimately costing a few thousand dollars will both replace and far outperform a 1,000-square-foot base station costing more than a million dollars.

Once again, in an entrepreneurial economy, crucial innovations come as an utter surprise to all the experts in the field. Donald Steinbrecher began in the Radio Astronomy Lab at MIT in the 1960s and early 1970s, creating receivers that could resolve a random cosmic ray among a mass of electromagnetic noise. This required radios with huge dynamic range—radios that could hear a feather drop at a heavy metal rock concert. He and his students solved this intractable problem by creating unique high-performance receivers and frequency "mixers." These could process huge spans of spectrum with immense variations of power and translate them without loss into intermediate frequencies. Then, computer systems convert the signals from analog to digital and analyze them with digital signal processors.

Moving out to begin his own company in 1973, Steinbrecher and his colleagues made several inventions in the fields of radar and digital signal analysis. At first, most of their customers were national security contractors in the intelligence field. For example, Steinbrecher supplied the radios for the ROTHR (remote over the horizon radar) systems that became famous for their role in the war against airborne drug traffic. Then in 1986, the company was asked if its equipment could work in the cellular band.

After cosmic rays and battlefield radar, the cellular band was easy. When he saw that the digital signal processors at the heart of his systems were dropping in price tenfold every two years, Steinbrecher knew that his esoteric radios could become a consumer product.

Translated to cellular, this technology opens entire new frontiers for wireless telephony. Rather than tuning into one fixed frequency as current cellular radios do, Steinbrecher's cells can use a high-dynamic-range digital radio to down-convert and digitize the entire cellular band. TDMA, CDMA, near or far, analog cellular, video, voice or data, in any combination, it makes no difference to the Steinbrecher system. His minicell converts them all at once to a digital bit stream. The DSPs take over from there, sorting out the TDMA and CDMA signals from the analog signals and reducing each to digital voice. To the extent the Steinbrecher system prevails, it would end the need for hybrid phones and make possible a phased shift to PCN or a variety of other digital services.

The future of wireless is boundless bandwidth, accomplished through the Shannon strategy of wide and weak signals, moving to ever smaller cells with lower power at higher frequencies.

Hoping to use Qualcomm chipsets and other technology, Steinbrecher could facilitate the acceptance of CDMA. For CDMA, the minicell provides a new, far cheaper radio front end that offers further relief to the near-far problem and is open to the diverse codes and fast-moving technologies of PCN. For the current cellular architecture, however, Steinbrecher offers only creative destruction, doing for large base stations what the integrated circuit did for racks of vacuum tubes in old telephone switches.

In essence, the new minicell replaces a rigid structure of giant analog mainframes with a system of wireless local area networks. Reconciling a variety of codes and technologies, the Steinbrecher devices resemble the smart hubs and routers from SynOptics Communications and Cisco Systems that are transforming the world of wired computer networks.

Best of all, at a time when the computer industry is preparing a massive invasion of the air, these wide and weak radios can handle voice, data and even video at the same time. Further, by cheaply accommodating a move from scores of large base stations to scores of thousands of minicells per city—on poles, down alleys or in elevator shafts—the system fulfills the promise of the computer revolution as a spectrum multiplier. Since each new minicell can use all the frequencies currently used by a large cell site, the multiplication of cells achieves a similar multiplication of bandwidth.

Finally, the Steinbrecher receivers can accommodate the coming move into higher frequencies. Banishing once and for all the concept of spectrum scarcity, these high-dynamic-range receivers can already handle frequencies up to the "W band" of 90 gigahertz and more.

Boundless Bandwidth

The future of wireless communications is boundless bandwidth, accomplished through the Shannon strategy of wide and weak signals, moving to ever smaller cells with lower power at higher frequencies. The PCN systems made possible by Qualcomm and Steinbrecher apply this approach chiefly to voice and data. Recent announcements by Bossard and Hovnanian extend the concept to television video as well. Last December, they disclosed that their company, Cellular Vision, was already wirelessly delivering 49 cable television channels to 350 homes near Brighton Beach, Long Island, in the 28-gigahertz band. They declared a plan to soon sign up some 5,000 new customers a month all over New York.

Among engineers in cellular and cable firms, Cellular Vision evokes the same responses of incredulity and denial familiar at Qualcomm and Steinbrecher. Like them, Bossard is resolutely on the right side of the Shannon and Shockley divide. In answer to the multitude of qualms and objections and demurrals, all three companies cite the huge benefits of more bandwidth. Qualcomm can assign some 416 times as much bandwidth to each call as a current cellular or TDMA system. Steinbrecher's minicell receivers can process 4,160 times as much bandwidth as an analog cell site or TDMA radio.

Hovnanian achieves some 300 times the bandwidth of a broadcast TV station and some three times the bandwidth of even a typical cable head end. For Hovnanian's so-called multipoint local distribution system, the FCC has allocated a total of two gigahertz between 27.5 and 29.5 gigahertz—one gigahertz for TV and one gigahertz for experimental data and phone service. This large swath of spectrum allows Cellular Vision to substitute bandwidth for power. Using FM rather than the AM system of cable, Cellular Vision gains the same kind of increased fidelity familiar in FM radio. Assigning 20 megahertz to each channel—three times the six megahertz of an analog system—Cellular Vision proves the potency of wide and weak by getting 20 decibels—some 10 times—more signal quality. These extra decibels come in handy in the rain.

As computer companies have already learned, phone and cable companies will discover that self-cannibalization is the only way to succeed in this era—the only way to stop others from capturing the prize.

With a radius of three miles, Cellular Vision cells are about 100 times smaller than telephone cells. Transmitting only 10 milliwatts per channel over a three-mile radius, the system gets far better signal-to-noise ratios than the three-watt radios of cellular phones or the multikilowatt systems of AM radio or television broadcasts. The millimeter wavelengths at 28 gigahertz allow narrowband high-gain antennas that lock onto the right signal and isolate it from neighboring cells. At 28 gigahertz, small antennas command the performance of much larger ones (for example, a six-inch antenna at 28 gigahertz is equivalent to a three-foot antenna at 4 gigahertz or a 300-foot antenna at broadcast television frequencies).

In Brighton Beach the receiving antennas, using a fixed-phased-array technology, are just four inches square, and the transmitting antennas deliver 49 channels from a one-inch omnidirectional device on a box the size of a suitcase. Between cells, these transmitters can send programming and other information through a conventional point-to-point microwave link.

Singing in the Rain

So what happens in the rain? Well, it seems that Cellular Vision does better than conventional cable. When you have small cells in geodesic low-power wireless networks using the full computational resources of modem microchips, you have plenty of extra decibels in your signal-to-noise budget to endure the most violent storms. Indeed, the 350 Brighton Beach customers of Cellular Vision received continuous service during the November 1992 near hurricane in New York, which brought floods that interrupted many cable networks for hours. One competitive advantage of Cellular Vision over cable seems to be less vulnerability to water.

Moving television radically toward the regime of wide and weak, Bossard and the Hovnanians have changed the dimensions of the air. However, they cannot escape the usual burdens of the innovator. Any drastic innovation must be some 10 times as good as what it replaces. Otherwise, the installed base, engineering momentum and customer loyalty of the incumbents will prevail against it.

Cellular Vision faces a wired cable system with some $18 billion in installed base. Already deploying fiber at a fast pace, cable companies plan to move within the next year toward digital compression schemes that increase capacity or resolution by a factor of between six and 10 (depending on the character of the programming). That means some 500 digital channels or more. TCI, the leading cable company, has ordered some one million cable converter and decompression boxes from General Instruments' Jerrold subsidiary for delivery late in 1993. In the U.S. cable industry, Hovnanian faces an aggressively moving target. Most cable experts doubt he can make much of a dent.

This view may be shortsighted. Clearly, Cellular Vision—and its likely imitators—can compete in the many areas with incompetent cable systems, in areas yet unreached by cable or in new projects launched by developers such as the Hovnanians. In the rest of the world, cable systems are rare. Cellular Vision is finding rich opportunities abroad, from Latvia to New Zealand. Most of all, as time passes, Cellular Vision might find itself increasingly well positioned for a world of untethered digital devices.

Such a cellular system could be adapted to mobile telephone or computer services. With a bit-error rate of one in 10 billion, it could theoretically transmit computer data without error correction. With one gigahertz of bandwidth, the system could function easily as a backbone for PCN applications, collecting calls from handsets operating at lower frequencies and passing them on to telephone or cellular central offices or to intelligent network facilities of the local phone companies.

The future local loop will combine telephone, teleputer and digital video services, together with speech recognition and other complex features, in patterns that will differ from neighborhood to neighborhood. Easily customizable from cell to cell, a system like Bossard's might well offer powerful advantages.

In an era of bandwidth abundance, the Negroponte switch–with voice pushed to the air and video onto wires–may well give way to this division between fibersphere and atmosphere. With the fibersphere offering virtually unlimited bandwidth for fixed communication over long distances, the local loop will be the bottleneck, thronged with millions of wireless devices. Under these conditions, a move to high-frequency cellular systems is imperative to carry the increasing floods of digital video overflowing from the fibersphere.

In any case, led by Qualcomm, Steinbrecher and Cellular Vision, a new generation of companies is emerging to challenge the assumptions and structures of the existing information economy. All these companies are recent startups, with innovations entirely unexpected by international standards bodies, university experts and government officials. They are the fruit of an entrepreneurial America, guided by the marketplace into the microcosm and telecosm.

Why Imitate European Failures? Meanwhile, the European and Japanese experiences with government-guided strategies should give pause to proponents of similar policies here. Thirty years of expensive industrial policy targeting computers has left the Europeans with no significant computer firms at all. The Japanese have done better, but even they have been losing market share across the board to the U.S.

In the converging crescendos of advance in digital wireless telephony and computing, progress is surging far beyond all the regulatory maps and guidebooks of previous years. If the entire capacity of the 28-gigahertz band, renewed every three miles, is open to telephony and video, bandwidth will be scarcely more limiting in wireless than it is in glass.

In this emerging world of boundless bandwidth, companies will prevail only by transcending the folklore of scarcity and embracing the full promise of the digital dawn. In an era of accelerating transition, the rule of success will be self-cannibalization. Wire-line phone companies are not truly profitable today; their reported earnings all spring from slow depreciation of installed plant and equipment that are fast becoming worthless. As George Calhoun of IMMC demonstrates in his superb new book, *Wireless Access and the Local Telephone Network* (Artech, 1992), new digital wireless connections are already less than one-third the cost of installing wire-line phones. For the RBOCs, aggressively attacking their own obsolescent enterprises is their only hope of prosperity.

As Joseph Schlosser of Coopers & Lybrand observes, self-cannibalization will not appear to be in the financial interests of the established firms; it will not prove out in net-present-value terms. There will be no studies to guarantee its success. Executives will have to earn their pay by going with their gut. As semiconductor and computer companies have already learned, phone and cable companies will discover that self-cannibalization is the only way to succeed in this era–the only way to stop others from capturing the heart of your business.

This is the lesson of the last decade. When Craig McCaw sold his cable properties and plunged into cellular telephony and $2 billion of Michael Milken's junk bond debt, there was no way to prove him right. Today AT&T is preparing to launch him as a rival to Bill Gates as the nation's richest man. Yet McCaw cannot rest on his laurels; the hour of the cannibal is at hand.

In theory, the transition should not be difficult for this resourceful and ingenious entrepreneur, who has long been a leading prophet of ubiquitous wireless phones and computers–his predicted personal digital assistant, "Charles." But a company that has paid billions for its 25-megahertz national swath of long and strong frequencies faces especially acute dilemmas in moving toward a regime of wide and weak. As a man–and company–that has made such transitions before, McCaw is favored by history and by AT&T. As a giant pillar of the new establishment, though, McCaw may find it as difficult to shift gears as did the computer establishment before him. The stakes are even higher. The next decade will see the emergence of fortunes in ever-changing transmutations of PCN, digital video, multimedia and wireless computers that dwarf the yields of cable and cellular. The window of opportunity opens wide and weak.

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